3. A sample of $CH_3CH_2NH_2$ is placed in an insulated container, where it decomposes into ethene and ammonia according to the reaction represented above.

Substance	Absolute Entropy, $S°$, in J/(mol·K) at 298 K
$CH_3CH_2NH_2(g)$	284.9
$CH_2CH_2(g)$	219.3
$NH_3(g)$	192.8

(a) Using the data in the table above, calculate the value, in $J/(mol_{rxn} \cdot K)$, of the standard entropy change, $\Delta S°$, for the reaction at 298 K.

(b) Using the data in the table below, calculate the value, in kJ/mol_{rxn}, of the standard enthalpy change, $\Delta H°$, for the reaction at 298 K.

Bond	C−C	C=C	C−H	C−N	N−H
Average Bond Enthalpy (kJ/mol)	348	614	413	293	391

(c) Based on your answer to part (b), predict whether the temperature of the contents of the insulated container will increase, decrease, or remain the same as the reaction proceeds. Justify your prediction.

An experiment is carried out to measure the rate of the reaction, which is first order. A 4.70×10^{-3} mol sample of $CH_3CH_2NH_2$ is placed in a previously evacuated 2.00 L container at 773 K. After 20.0 minutes, the concentration of the $CH_3CH_2NH_2$ is found to be 3.60×10^{-4} mol/L.

(d) Calculate the rate constant for the reaction at 773 K. Include units with your answer.

(e) Calculate the initial rate, in $M\ min^{-1}$, of the reaction at 773 K.

(f) If $\frac{1}{[CH_3CH_2NH_2]}$ is plotted versus time for this reaction, would the plot result in a straight line or would it result in a curve? Explain your reasoning.

STOP

If you finish before time is called, you may check your work on this part only.
Do not turn to the other part of the test until you are told to do so.

CHEMISTRY

Part B

Time—40 minutes

NO CALCULATORS MAY BE USED FOR PART B.

Answer Question 4 below. The Section II score weighting for this question is 10 percent.

4. For each of the following three reactions, write a balanced equation for the reaction in part (i) and answer the question about the reaction in part (ii). In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You may use the empty space at the bottom of the next page for scratch work, but only equations that are written in the answer boxes provided will be scored.

EXAMPLE:

A strip of magnesium metal is added to a solution of silver(I) nitrate.

(i) Balanced equation:

$Mg + 2Ag^{+} \rightarrow Mg^{2+} + 2Ag$

(ii) Which substance is oxidized in the reaction?

Mg is oxidized.

(a) A piece of solid strontium carbonate is dropped into a 0.1 M solution of hydrochloric acid.

(i) Balanced equation:

(ii) Indicate one thing that would be observed as the reaction occurs.

(b) Magnesium metal is strongly heated in oxygen gas.

(i) Balanced equation:

(ii) What is the oxidation number of magnesium before the reaction occurs, and what is the oxidation number of magnesium after the reaction is complete?

(c) A solution of nickel(II) chloride is added to a solution of sodium hydroxide, forming a precipitate.

(i) Balanced equation:

(ii) If equal volumes of 1.0 M nickel(II) chloride and 1.0 M sodium hydroxide are used, what ion is present in the solution in the highest concentration after the precipitate forms?

YOU MAY USE THE SPACE BELOW FOR SCRATCH WORK, BUT ONLY EQUATIONS THAT ARE WRITTEN IN THE ANSWER BOXES PROVIDED WILL BE SCORED.

2. An 8.55 mol sample of methanol, CH_3OH, is placed in a 15.0 L evacuated rigid tank and heated to 327°C. At that temperature, all of the methanol is vaporized and some of the methanol decomposes to form carbon monoxide gas and hydrogen gas, as represented in the equation below.

$$CH_3OH(g) \rightleftarrows CO(g) + 2\,H_2(g)$$

(a) The reaction mixture contains 6.30 mol of $CO(g)$ at equilibrium at 327°C.

(i) Calculate the number of moles of $H_2(g)$ in the tank.

(ii) Calculate the number of grams of $CH_3OH(g)$ remaining in the tank.

(iii) Calculate the mole fraction of $H_2(g)$ in the tank.

(iv) Calculate the total pressure, in atm, in the tank at 327°C.

(b) Consider the three gases in the tank at 327°C: $CH_3OH(g)$, $CO(g)$, and $H_2(g)$.

(i) How do the average kinetic energies of the molecules of the gases compare? Explain.

(ii) Which gas has the highest average molecular speed? Explain.

(c) The tank is cooled to 25°C, which is well below the boiling point of methanol. It is found that small amounts of $H_2(g)$ and $CO(g)$ have dissolved in the liquid CH_3OH. Which of the two gases would you expect to be more soluble in methanol at 25°C ? Justify your answer.

GO ON TO THE NEXT PAGE.

3. Answer the following questions about glucose, $C_6H_{12}O_6$, an important biochemical energy source.

(a) Write the empirical formula of glucose.

In many organisms, glucose is oxidized to carbon dioxide and water, as represented by the following equation.

$$C_6H_{12}O_6(s) + 6\,O_2(g) \rightarrow 6\,CO_2(g) + 6\,H_2O(l)$$

A 2.50 g sample of glucose and an excess of $O_2(g)$ were placed in a calorimeter. After the reaction was initiated and proceeded to completion, the total heat released by the reaction was calculated to be 39.0 kJ.

(b) Calculate the value of $\Delta H°$, in kJ mol^{-1}, for the combustion of glucose.

(c) When oxygen is not available, glucose can be oxidized by fermentation. In that process, ethanol and carbon dioxide are produced, as represented by the following equation.

$$C_6H_{12}O_6(s) \rightarrow 2\,C_2H_5OH(l) + 2\,CO_2(g) \qquad \Delta H° = -68.0 \text{ kJ mol}^{-1} \text{ at } 298 \text{ K}$$

The value of the equilibrium constant, K_p, for the reaction at 298 K is 8.9×10^{39}.

(i) Calculate the value of the standard free-energy change, $\Delta G°$, for the reaction at 298 K. Include units with your answer.

(ii) Calculate the value of the standard entropy change, $\Delta S°$, in J K^{-1} mol^{-1}, for the reaction at 298 K.

(iii) Indicate whether the equilibrium constant for the fermentation reaction increases, decreases, or remains the same if the temperature is increased. Justify your answer.

(d) Using your answer for part (b) and the information provided in part (c), calculate the value of $\Delta H°$ for the following reaction.

$$C_2H_5OH(l) + 3\,O_2(g) \rightarrow 2\,CO_2(g) + 3\,H_2O(l)$$

STOP

If you finish before time is called, you may check your work on this part only. Do not turn to the other part of the test until you are told to do so.

CHEMISTRY
Part B
Time—40 minutes
NO CALCULATORS MAY BE USED FOR PART B.

Answer Question 4 below. The Section II score weighting for this question is 10 percent.

4. For each of the following three reactions, write a balanced equation in part (i) and answer the question in part (ii). In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You may use the empty space at the bottom of the next page for scratch work, but only equations that are written in the answer boxes provided will be scored.

EXAMPLE:
A strip of magnesium metal is added to a solution of silver(I) nitrate.

(i) Balanced equation:
$Mg + 2\,Ag^+ \longrightarrow Mg^{2+} + 2\,Ag$

(ii) Which substance is oxidized in the reaction?
Mg is oxidized.

(a) Zinc metal is added to a hydrobromic acid solution.

(i) Balanced equation:

(ii) Write the oxidation half-reaction for the reaction.

GO ON TO THE NEXT PAGE.

(b) Solid lithium oxide is added to distilled water.

(i) Balanced equation:

(ii) Indicate whether the pH of the resulting solution is less than 7, equal to 7, or greater than 7. Explain.

(c) A 100 mL sample of 1 *M* strontium chloride solution is mixed with a 100 mL sample of 1 *M* sodium carbonate solution, resulting in the formation of a precipitate.

(i) Balanced equation:

(ii) Describe what will occur if the precipitate is dried and a few drops of 1 *M* hydrochloric acid are added. Explain.

GO ON TO THE NEXT PAGE.

Answer Question 5 and Question 6. The Section II score weighting for these questions is 15 percent each.

Your responses to these questions will be scored on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

5. A student is instructed to prepare 100.0 mL of 1.250 *M* NaOH from a stock solution of 5.000 *M* NaOH. The student follows the proper safety guidelines.

(a) Calculate the volume of 5.000 *M* NaOH needed to accurately prepare 100.0 mL of 1.250 *M* NaOH solution.

(b) Describe the steps in a procedure to prepare 100.0 mL of 1.250 *M* NaOH solution using 5.000 *M* NaOH and equipment selected from the list below.

Balance	25 mL Erlenmeyer flask	100 mL graduated cylinder	100 mL volumetric flask
50 mL buret	100 mL Florence flask	25 mL pipet	100 mL beaker
Eyedropper	Drying oven	Wash bottle of distilled H_2O	Crucible

(c) The student is given 50.0 mL of a 1.00 *M* solution of a weak, monoprotic acid, HA. The solution is titrated with the 1.250 *M* NaOH to the endpoint. (Assume that the endpoint is at the equivalence point.)

(i) Explain why the solution is basic at the equivalence point of the titration. Include a chemical equation as part of your explanation.

(ii) Identify the indicator in the table below that would be best for the titration. Justify your choice.

Indicator	pK_a
Methyl red	5
Bromothymol blue	7
Phenolphthalein	9

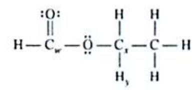
(d) The student is given another 50.0 mL sample of 1.00 *M* HA, which the student adds to the solution that had been titrated to the endpoint in part (c). The result is a solution with a pH of 5.0.

(i) What is the value of the acid-dissociation constant, K_a, for the weak acid? Explain your reasoning.

(ii) Explain why the addition of a few drops of 1.250 *M* NaOH to the resulting solution does not appreciably change its pH.

6. Use principles of molecular structure, intermolecular forces, and kinetic molecular theory to answer the following questions.

(a) A complete Lewis electron-dot diagram of a molecule of ethyl methanoate is given below.



(i) Identify the hybridization of the valence electrons of the carbon atom labeled C_w.

(ii) Estimate the numerical value of the $H_y - C_x - O$ bond angle in an ethyl methanoate molecule. Explain the basis of your estimate.

(b) Ethyl methanoate, CH_3CH_2OCHO, is synthesized in the laboratory from ethanol, C_2H_5OH, and methanoic acid, HCOOH, as represented by the following equation.

$$C_2H_5OH(l) + HCOOH(l) \rightleftarrows CH_3CH_2OCHO(l) + H_2O(l)$$

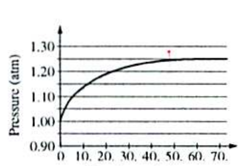
(i) In the box below, draw the complete Lewis electron-dot diagram of a methanoic acid molecule.

Methanoic Acid

(ii) In the box below, draw the complete Lewis electron-dot diagrams of a methanoic acid molecule and a water molecule in an orientation that allows a hydrogen bond to form between them.

Hydrogen Bonding Between Methanoic Acid and Water

(c) A small amount of liquid ethyl methanoate (boiling point 54°C) was placed in a rigid closed 2.0 L container containing argon gas at an initial pressure of 1.00 atm and a temperature of 20°C. The pressure in the container was monitored for 70. seconds after the ethyl methanoate was added, and the data in the graph below were obtained. It was observed that some liquid ethyl methanoate remained in the flask after 70. seconds. (Assume that the volume of the remaining liquid is negligible compared to the total volume of the container.)



(i) Explain why the pressure in the flask increased during the first 60. seconds.

(ii) Explain, in terms of processes occurring at the molecular level, why the pressure in the flask remained constant after 60. seconds.

(iii) What is the value of the partial pressure of ethyl methanoate vapor in the container at 60. seconds?

(iv) After 80. seconds, additional liquid ethyl methanoate is added to the container at 20°C. Does the partial pressure of the ethyl methanoate vapor in the container increase, decrease, or stay the same? Explain. (Assume that the volume of the additional liquid ethyl methanoate in the container is negligible compared to the total volume of the container.)

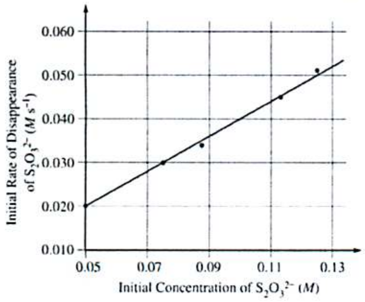
STOP

END OF EXAM

$$S_2O_3^{2-}(aq) \xrightarrow{H^+} SO_3^{2-}(aq) + S(s)$$

2. A student performed an experiment to investigate the decomposition of sodium thiosulfate, $Na_2S_2O_3$, in acidic solution, as represented by the equation above. In each trial the student mixed a different concentration of sodium thiosulfate with hydrochloric acid at constant temperature and determined the rate of disappearance of $S_2O_3^{2-}(aq)$. Data from five trials are given below in the table on the left and are plotted in the graph on the right.

Trial	Initial Concentration of $S_2O_3^{2-}(aq)$ (M)	Initial Rate of Disappearance of $S_2O_3^{2-}(aq)$ ($M\ s^{-1}$)
1	0.050	0.020
2	0.075	0.030
3	0.088	0.034
4	0.112	0.045
5	0.125	0.051



(a) Identify the independent variable in the experiment.

(b) Determine the order of the reaction with respect to $S_2O_3^{2-}$. Justify your answer by using the information above.

(c) Determine the value of the rate constant, k, for the reaction. Include units in your answer. Show how you arrived at your answer.

(d) In another trial the student mixed 0.10 M $Na_2S_2O_3$ with hydrochloric acid. Calculate the amount of time it would take for the concentration of $S_2O_3^{2-}$ to drop to 0.020 M.

(e) On the graph above, sketch the line that shows the results that would be expected if the student repeated the five trials at a temperature lower than that during the first set of trials.

$$2\,H_2O_2(aq) \rightarrow 2\,H_2O(l) + O_2(g)$$

3. The mass of an aqueous solution of H_2O_2 is 6.951 g. The H_2O_2 in the solution decomposes completely according to the reaction represented above. The $O_2(g)$ produced is collected in an inverted graduated tube over water at 23.4°C and has a volume of 182.4 mL when the water levels inside and outside of the tube are the same. The atmospheric pressure in the lab is 762.6 torr, and the equilibrium vapor pressure of water at 23.4°C is 21.6 torr.

(a) Calculate the partial pressure, in torr, of $O_2(g)$ in the gas-collection tube.

(b) Calculate the number of moles of $O_2(g)$ produced in the reaction.

(c) Calculate the mass, in grams, of H_2O_2 that decomposed.

(d) Calculate the percent of H_2O_2, by mass, in the original 6.951 g aqueous sample.

(e) Write the oxidation number of the oxygen atoms in H_2O_2 and the oxidation number of the oxygen atoms in O_2 in the appropriate cells in the table below.

Substance	Oxidation Number of Oxygen Atoms
H_2O_2	
O_2	

(f) Write the balanced oxidation half-reaction for the reaction.

STOP

If you finish before time is called, you may check your work on this part only.
Do not turn to the other part of the test until you are told to do so.

CHEMISTRY
Part B
Time—40 minutes
NO CALCULATORS MAY BE USED FOR PART B.

Answer Question 4 below. The Section II score weighting for this question is 10 percent.

4. For each of the following three reactions, write a balanced equation in part (i) and answer the question in part (ii). In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You may use the empty space at the bottom of the next page for scratch work, but only equations that are written in the answer boxes provided will be graded.

EXAMPLE:
A strip of magnesium metal is added to a solution of silver(I) nitrate.

(i) Balanced equation:
$Mg + 2\,Ag^+ \longrightarrow Mg^{2+} + 2\,Ag$

(ii) Which substance is oxidized in the reaction?
Mg is oxidized.

(a) A barium nitrate solution and a potassium fluoride solution are combined and a precipitate forms.

(i) Balanced equation:

(ii) If equimolar amounts of barium nitrate and potassium fluoride are combined, which reactant, if any, is the limiting reactant? Explain.

(b) A piece of cadmium metal is oxidized by adding it to a solution of copper(II) chloride.

(i) Balanced equation:

(ii) List two visible changes that would occur in the reaction container as the reaction is proceeding.

(c) A hydrolysis reaction occurs when solid sodium sulfide is added to distilled water.

(i) Balanced equation:

(ii) Indicate whether the pH of the resulting solution is less than 7, equal to 7, or greater than 7. Explain.

Your responses to the rest of the questions in this part of the examination will be graded on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

Answer BOTH Question 5 below AND Question 6 printed on page 11. Both of these questions will be graded. The Section II score weighting for these questions is 30 percent (15 percent each).

5. An experiment is performed to determine the molar mass of an unknown solid monoprotic acid, HA, by titration with a standardized NaOH solution.

(a) What measurement(s) must be made to determine the number of moles of NaOH used in the titration?

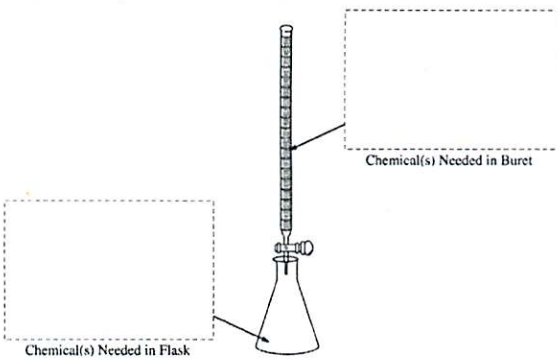
(b) Write a mathematical expression that can be used to determine the number of moles of NaOH used to reach the endpoint of the titration.

(c) How can the number of moles of HA consumed in the titration be determined?

(d) In addition to the measurement(s) made in part (a), what other measurement(s) must be made to determine the molar mass of the acid, HA ?

(e) Write the mathematical expression that is used to determine the molar mass of HA.

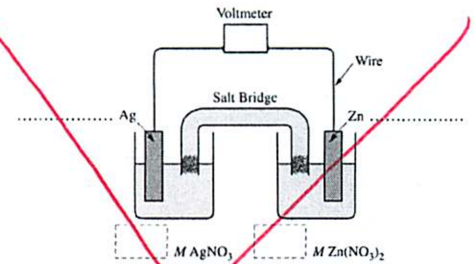
(f) The following diagram represents the setup for the titration. In the appropriate boxes below, list the chemical(s) needed to perform the titration.



(g) Explain what effect each of the following would have on the calculated molar mass of HA. Justify your answers.

(i) The original solid acid, HA, was not completely dry at the beginning of the experiment.

(ii) The procedure called for 25 mL of H_2O in the Erlenmeyer flask, but a student used 35 mL of H_2O.



6. The following questions refer to the electrochemical cell shown in the diagram above.

(a) Write a balanced net ionic equation for the spontaneous reaction that takes place in the cell.

(b) Calculate the standard cell potential, $E°$, for the reaction in part (a).

(c) In the diagram above,

(i) label the anode and the cathode on the dotted lines provided, and

(ii) indicate, in the boxes below the half-cells, the concentration of $AgNO_3$ and the concentration of $Zn(NO_3)_2$ that are needed to generate $E°$.

(d) How will the cell potential be affected if KI is added to the silver half-cell? Justify your answer.

Answer EITHER Question 7 below OR Question 8 printed on page 13. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.

$$N_2(g) + 2\,H_2(g) \rightleftarrows N_2H_4(g) \quad \Delta H^\circ_{298} = +95.4\ \text{kJ mol}^{-1}\ ;\ \Delta S^\circ_{298} = -176\ \text{J K}^{-1}\ \text{mol}^{-1}$$

7. Answer the following questions about the reaction represented above using principles of thermodynamics.

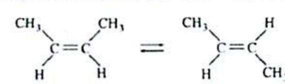
(a) On the basis of the thermodynamic data given above, compare the sum of the bond strengths of the reactants to the sum of the bond strengths of the product. Justify your answer.

(b) Does the entropy change of the reaction favor the reactants or the product? Justify your answer.

(c) For the reaction under the conditions specified, which is favored, the reactants or the product? Justify your answer.

(d) Explain how to determine the value of the equilibrium constant, K_{eq}, for the reaction. (Do not do any calculations.)

(e) Predict whether the value of K_{eq} for the reaction is greater than 1, equal to 1, or less than 1. Justify your answer.



cis-2-butene ⇌ *trans*-2-butene

8. The gas-phase conversion reaction between the geometric isomers *cis*-2-butene and *trans*-2-butene is represented by the equation above. The value of the equilibrium constant, K_{eq}, for the reaction is 3.2 at 298 K and 1.0 atm.

(a) In a mixture of the isomers at equilibrium at 298 K and 1.0 atm, which is present at a higher concentration, *cis*-2-butene or *trans*-2-butene? Justify your answer.

(b) If 1.00 mol of pure *cis*-2-butene and 1.0 mol of pure *trans*-2-butene were introduced into an evacuated container at 298 K, in which direction (to the right or to the left) would the reaction proceed to establish equilibrium? Justify your answer.

(c) Given that K_{eq} for the reaction at 400 K has the value 1.3, predict whether the reaction is endothermic or exothermic. Justify your answer.

(d) There are other structural isomers of *cis*-2-butene and *trans*-2-butene. Draw one of these isomers, including all atoms, and give its IUPAC name.

END OF EXAMINATION

6. Answer the following questions that relate to chemical bonding.

(a) In the boxes provided, draw the complete Lewis structure (electron-dot diagram) for each of the three molecules represented below.

CF_4	PF_5	SF_4

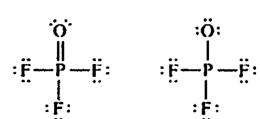
(b) On the basis of the Lewis structures drawn above, answer the following questions about the particular molecule indicated.

(i) What is the F–C–F bond angle in CF_4 ?

(ii) What is the hybridization of the valence orbitals of P in PF_5 ?

(iii) What is the geometric shape formed by the atoms in SF_4 ?

(c) Two Lewis structures can be drawn for the OPF_3 molecule, as shown below.



Structure 1 Structure 2

(i) How many sigma bonds and how many pi bonds are in structure 1 ?

(ii) Which one of the two structures best represents a molecule of OPF_3 ? Justify your answer in terms of formal charge.

GO ON TO THE NEXT PAGE.

Answer EITHER Question 7 below OR Question 8 printed on page 14. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.

7. Use principles of atomic structure, bonding, and/or intermolecular forces to respond to each of the following. Your responses <u>must</u> include specific information about <u>all</u> substances referred to in each question.

(a) At a pressure of 1 atm, the boiling point of $NH_3(l)$ is 240 K, whereas the boiling point of $NF_3(l)$ is 144 K.

(i) Identify the intermolecular force(s) in each substance.

(ii) Account for the difference in the boiling points of the substances.

(b) The melting point of $KCl(s)$ is 776°C, whereas the melting point of $NaCl(s)$ is 801°C.

(i) Identify the type of bonding in each substance.

(ii) Account for the difference in the melting points of the substances.

(c) As shown in the table below, the first ionization energies of Si, P, and Cl show a trend.

Element	First Ionization Energy ($kJ\ mol^{-1}$)
Si	786
P	1,012
Cl	1,251

(i) For each of the three elements, identify the quantum level (e.g., $n = 1$, $n = 2$, etc.) of the valence electrons in the atom.

(ii) Explain the reasons for the trend in first ionization energies.

(d) A certain element has two stable isotopes. The mass of one of the isotopes is 62.93 amu and the mass of the other isotope is 64.93 amu.

(i) Identify the element. Justify your answer.

(ii) Which isotope is more abundant? Justify your answer.

GO ON TO THE NEXT PAGE.

CHEMISTRY
Section II
(Total time—95 minutes)

Part A
Time—55 minutes
YOU MAY USE YOUR CALCULATOR FOR PART A.

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS. It is to your advantage to do this, since you may obtain partial credit if you do and you will receive little or no credit if you do not. Attention should be paid to significant figures.

Be sure to write all your answers to the questions on the lined pages following each question in the goldenrod booklet. Do NOT write your answers on the lavender insert.

Answer Questions 1, 2, and 3. The Section II score weighting for each question is 20 percent.

1. A sample of solid U_3O_8 is placed in a rigid 1.500 L flask. Chlorine gas, $Cl_2(g)$, is added, and the flask is heated to 862°C. The equation for the reaction that takes place and the equilibrium-constant expression for the reaction are given below.

$$U_3O_8(s) + 3\,Cl_2(g) \rightleftarrows 3\,UO_2Cl_2(g) + O_2(g) \qquad K_p = \frac{(p_{UO_2Cl_2})^3(p_{O_2})}{(p_{Cl_2})^3}$$

When the system is at equilibrium, the partial pressure of $Cl_2(g)$ is 1.007 atm and the partial pressure of $UO_2Cl_2(g)$ is 9.734×10^{-4} atm.

(a) Calculate the partial pressure of $O_2(g)$ at equilibrium at 862°C.

(b) Calculate the value of the equilibrium constant, K_p, for the system at 862°C.

(c) Calculate the Gibbs free-energy change, $\Delta G°$, for the reaction at 862°C.

(d) State whether the entropy change, $\Delta S°$, for the reaction at 862°C is positive, negative, or zero. Justify your answer.

(e) State whether the enthalpy change, $\Delta H°$, for the reaction at 862°C is positive, negative, or zero. Justify your answer.

(f) After a certain period of time, 1.000 mol of $O_2(g)$ is added to the mixture in the flask. Does the mass of $U_3O_8(s)$ in the flask increase, decrease, or remain the same? Justify your answer.

CHEMISTRY
Part B
Time—40 minutes
NO CALCULATORS MAY BE USED FOR PART B.

Answer Question 4 below. The Section II score weighting for this question is 10 percent.

4. For each of the following three reactions, in part (i) write a balanced equation for the reaction and in part (ii) answer the question about the reaction. In part (i), coefficients should be in terms of lowest whole numbers. Assume that solutions are aqueous unless otherwise indicated. Represent substances in solutions as ions if the substances are extensively ionized. Omit formulas for any ions or molecules that are unchanged by the reaction. You may use the empty space at the bottom of the next page for scratch work, but only equations that are written in the answer boxes provided will be graded.

EXAMPLE:
A strip of magnesium metal is added to a solution of silver(I) nitrate.

(i) Balanced equation:
$Mg + 2\,Ag^+ \longrightarrow Mg^{2+} + 2\,Ag$

(ii) Which substance is oxidized in the reaction?
Mg is oxidized.

(a) Solid ammonium carbonate decomposes as it is heated.

(i) Balanced equation:

(ii) Predict the algebraic sign of $\Delta S°$ for the reaction. Explain your reasoning.

(b) Chlorine gas, an oxidizing agent, is bubbled into a solution of potassium bromide.

(i) Balanced equation:

(ii) What is the oxidation number of chlorine before the reaction occurs? What is the oxidation number of chlorine after the reaction occurs?

(c) A small piece of sodium is placed in a beaker of distilled water.

(i) Balanced equation:

(ii) The reaction is exothermic, and sometimes small flames are observed as the sodium reacts with the water. Identify the product of the reaction that burns to produce the flames.

	First Ionization Energy (kJ mol^{-1})	Second Ionization Energy (kJ mol^{-1})	Third Ionization Energy (kJ mol^{-1})
Element 1	1,251	2,300	3,820
Element 2	496	4,560	6,910
Element 3	738	1,450	7,730
Element 4	1,000	2,250	3,360

6. The table above shows the first three ionization energies for atoms of four elements from the third period of the periodic table. The elements are numbered randomly. Use the information in the table to answer the following questions.

(a) Which element is most metallic in character? Explain your reasoning.

(b) Identify element 3. Explain your reasoning.

(c) Write the complete electron configuration for an atom of element 3.

(d) What is the expected oxidation state for the most common ion of element 2 ?

(e) What is the chemical symbol for element 2 ?

(f) A neutral atom of which of the four elements has the smallest radius?

STOP

END OF EXAM

Your responses to the rest of the questions in this part of the examination will be graded on the basis of the accuracy and relevance of the information cited. Explanations should be clear and well organized. Examples and equations may be included in your responses where appropriate. Specific answers are preferable to broad, diffuse responses.

Answer BOTH Question 5 below AND Question 6 printed on page 12. Both of these questions will be graded. The Section II score weighting for these questions is 30 percent (15 percent each).

$$2\ Al(s) + 2\ KOH(aq) + 4\ H_2SO_4(aq) + 22\ H_2O(l) \rightarrow 2\ KAl(SO_4)_2\cdot 12H_2O(s) + 3\ H_2(g)$$

5. In an experiment, a student synthesizes alum, $KAl(SO_4)_2\cdot 12H_2O(s)$, by reacting aluminum metal with potassium hydroxide and sulfuric acid, as represented in the balanced equation above.

(a) In order to synthesize alum, the student must prepare a 5.0 *M* solution of sulfuric acid. Describe the procedure for preparing 50.0 mL of 5.0 *M* H_2SO_4 using any of the chemicals and equipment listed below. Indicate specific amounts and equipment where appropriate.

10.0 *M* H_2SO_4	50.0 mL volumetric flask
Distilled water	50.0 mL buret
100 mL graduated cylinder	25.0 mL pipet
100 mL beaker	50 mL beaker

(b) Calculate the minimum volume of 5.0 *M* H_2SO_4 that the student must use to react completely with 2.7 g of aluminum metal.

(c) As the reaction solution cools, alum crystals precipitate. The student filters the mixture and dries the crystals, then measures their mass.

(i) If the student weighs the crystals before they are completely dry, would the calculated percent yield be greater than, less than, or equal to the actual percent yield? Explain.

(ii) Cooling the reaction solution in an ice bath improves the percent yield obtained. Explain.

(d) The student heats crystals of pure alum, $KAl(SO_4)_2\cdot 12H_2O(s)$, in an open crucible to a constant mass. The mass of the sample after heating is less than the mass before heating. Explain.

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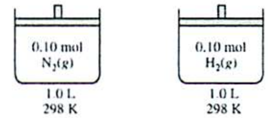


6. Consider two containers of volume 1.0 L at 298 K, as shown above. One container holds 0.10 mol $N_2(g)$ and the other holds 0.10 mol $H_2(g)$. The average kinetic energy of the $N_2(g)$ molecules is 6.2×10^{-21} J. Assume that the $N_2(g)$ and the $H_2(g)$ exhibit ideal behavior.

(a) Is the pressure in the container holding the $H_2(g)$ less than, greater than, or equal to the pressure in the container holding the $N_2(g)$? Justify your answer.

(b) What is the average kinetic energy of the $H_2(g)$ molecules?

(c) The molecules of which gas, N_2 or H_2, have the greater average speed? Justify your answer.

(d) What change could be made that would decrease the average kinetic energy of the $N_2(g)$ molecules in the container?

(e) If the volume of the container holding the $H_2(g)$ was decreased to 0.50 L at 298 K, what would be the change in each of the following variables? In each case, justify your answer.

(i) The pressure within the container

(ii) The average speed of the $H_2(g)$ molecules

GO ON TO THE NEXT PAGE.

Answer EITHER Question 7 below OR Question 8 printed on page 14. Only one of these two questions will be graded. If you start both questions, be sure to cross out the question you do not want graded. The Section II score weighting for the question you choose is 15 percent.

7. Answer the following questions about thermodynamics.

Substance	Combustion Reaction	Enthalpy of Combustion, ΔH°_{comb}, at 298 K (kJ mol^{-1})
$H_2(g)$	$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$	−290
$C(s)$	$C(s) + O_2(g) \rightarrow CO_2(g)$	−390
$CH_3OH(l)$		−730

(a) In the empty box in the table above, write a balanced chemical equation for the complete combustion of one mole of $CH_3OH(l)$. Assume products are in their standard states at 298 K. Coefficients do not need to be whole numbers.

(b) On the basis of your answer to part (a) and the information in the table, determine the enthalpy change for the reaction $C(s) + H_2(g) + H_2O(l) \rightarrow CH_3OH(l)$.

(c) Write the balanced chemical equation that shows the reaction that is used to determine the enthalpy of formation for one mole of $CH_3OH(l)$.

(d) Predict the sign of ΔS° for the combustion of $H_2(g)$. Explain your reasoning.

(e) On the basis of bond energies, explain why the combustion of $H_2(g)$ is exothermic.

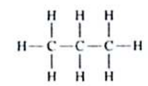
GO ON TO THE NEXT PAGE.

8. Use principles of atomic structure, bonding, and intermolecular forces to answer the following questions. Your responses must include specific information about all substances referred to in each part.

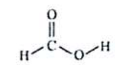
(a) Draw a complete Lewis electron-dot structure for the CS_2 molecule. Include all valence electrons in your structure.

(b) The carbon-to-sulfur bond length in CS_2 is 160 picometers. Is the carbon-to-selenium bond length in CSe_2 expected to be greater than, less than, or equal to this value? Justify your answer.

(c) The bond energy of the carbon-to-sulfur bond in CS_2 is 577 kJ mol^{-1}. Is the bond energy of the carbon-to-selenium bond in CSe_2 expected to be greater than, less than, or equal to this value? Justify your answer.



Propane



Methanoic Acid

(d) The complete structural formulas of propane, C_3H_8, and methanoic acid, HCOOH, are shown above. In the table below, write the type(s) of intermolecular attractive force(s) that occur in each substance.

Substance	Boiling Point	Intermolecular Attractive Force(s)
Propane	229 K	
Methanoic acid	374 K	

(e) Use principles of intermolecular attractive forces to explain why methanoic acid has a higher boiling point than propane.

END OF EXAM

CHEMISTRY

Section II

(Total time—95 minutes)

Part A

Time—55 minutes

YOU MAY USE YOUR CALCULATOR FOR PART A.

CLEARLY SHOW THE METHOD USED AND THE STEPS INVOLVED IN ARRIVING AT YOUR ANSWERS. It is to your advantage to do this, since you may obtain partial credit if you do and you will receive little or no credit if you do not. Attention should be paid to significant figures.

Be sure to write all your answers to the questions on the lined pages following each question in the booklet with the pink cover. Do NOT write your answers on the green insert.

Answer Questions 1, 2, and 3. The Section II score weighting for each question is 20 percent.

$$C(s) + CO_2(g) \rightleftarrows 2\,CO(g)$$

1. Solid carbon and carbon dioxide gas at 1,160 K were placed in a rigid 2.00 L container, and the reaction represented above occurred. As the reaction proceeded, the total pressure in the container was monitored. When equilibrium was reached, there was still some C(*s*) remaining in the container. Results are recorded in the table below.

Time (hours)	Total Pressure of Gases in Container at 1,160 K (atm)
0.0	5.00
2.0	6.26
4.0	7.09
6.0	7.75
8.0	8.37
10.0	8.37

(a) Write the expression for the equilibrium constant, K_p, for the reaction.

(b) Calculate the number of moles of $CO_2(g)$ initially placed in the container. (Assume that the volume of the solid carbon is negligible.)

GO ON TO THE NEXT PAGE.

(c) For the reaction mixture at equilibrium at 1,160 K, the partial pressure of the $CO_2(g)$ is 1.63 atm. Calculate

(i) the partial pressure of CO(*g*), and

(ii) the value of the equilibrium constant, K_p.

(d) If a suitable solid catalyst were placed in the reaction vessel, would the final total pressure of the gases at equilibrium be greater than, less than, or equal to the final total pressure of the gases at equilibrium without the catalyst? Justify your answer. (Assume that the volume of the solid catalyst is negligible.)

In another experiment involving the same reaction, a rigid 2.00 L container initially contains 10.0 g of C(*s*), plus CO(*g*) and $CO_2(g)$, each at a partial pressure of 2.00 atm at 1,160 K.

(e) Predict whether the partial pressure of $CO_2(g)$ will increase, decrease, or remain the same as this system approaches equilibrium. Justify your prediction with a calculation.

GO ON TO THE NEXT PAGE.

2. Answer the following questions relating to gravimetric analysis.

In the first of two experiments, a student is assigned the task of determining the number of moles of water in one mole of $MgCl_2 \cdot n\,H_2O$. The student collects the data shown in the following table.

Mass of empty container	22.347 g
Initial mass of sample and container	25.825 g
Mass of sample and container after first heating	23.982 g
Mass of sample and container after second heating	23.976 g
Mass of sample and container after third heating	23.977 g

(a) Explain why the student can correctly conclude that the hydrate was heated a sufficient number of times in the experiment.

(b) Use the data above to

(i) calculate the total number of moles of water lost when the sample was heated, and

(ii) determine the formula of the hydrated compound.

(c) A different student heats the hydrate in an uncovered crucible, and some of the solid spatters out of the crucible. This spattering will have what effect on the calculated mass of the water lost by the hydrate? Justify your answer.

In the second experiment, a student is given 2.94 g of a mixture containing anhydrous $MgCl_2$ and KNO_3. To determine the percentage by mass of $MgCl_2$ in the mixture, the student uses excess $AgNO_3(aq)$ to precipitate the chloride ion as AgCl(*s*).

(d) Starting with the 2.94 g sample of the mixture dissolved in water, briefly describe the steps necessary to quantitatively determine the mass of the AgCl precipitate.

(e) The student determines the mass of the AgCl precipitate to be 5.48 g. On the basis of this information, calculate each of the following.

(i) The number of moles of $MgCl_2$ in the original mixture

(ii) The percent by mass of $MgCl_2$ in the original mixture

GO ON TO THE NEXT PAGE.

A rate study of the reaction yielded the data recorded in the table below.

Experiment	Initial Concentration of NO (mol L^{-1})	Initial Concentration of O_2 (mol L^{-1})	Initial Rate of Formation of NO_2 (mol L^{-1} s^{-1})
1	0.0200	0.0300	8.52×10^{-2}
2	0.0200	0.0900	2.56×10^{-1}
3	0.0600	0.0300	7.67×10^{-1}

(d) Determine the order of the reaction with respect to each of the following reactants. Give details of your reasoning, clearly explaining or showing how you arrived at your answers.

(i) NO

(ii) O_2

(e) Write the expression for the rate law for the reaction as determined from the experimental data.

(f) Determine the value of the rate constant for the reaction, clearly indicating the units.

STOP

If you finish before time is called, you may check your work on this part only. Do not turn to the other part of the test until you are told to do so.

AP OR Midterm Review Probs

2012 Q3 a) N/A

b) $\Delta H = \Sigma BE_{React} - \Sigma BE_{prod}$

$(1 \cdot C\text{-}C) + 8(C\text{-}H) + 1\ C\text{-}N + \cancel{2N\text{-}H}) - \cancel{4(C\text{-}H)} + 1\ C{=}C + \cancel{3}N\text{-}H$

$(348kJ + 413kJ + 293kJ) - (614kJ + 391kJ) = \boxed{+49kJ}$

c) decrease. The ΔH is positive so E will be absorbed from surroundings and T will go down. (Rxn endothermic)

d) $\ln(3.60 \times 10^{-4} M) = -k(20.0 min) + \ln\left(\frac{4.70 \times 10^{-3} mol}{2.0L}\right)$

$\boxed{k = 0.0938 \frac{1}{s}}$

e Rate $= k[CH_3CH_2NH_2] = (0.0938 \frac{1}{s})\left(\frac{4.70 \times 10^{-3} mol}{2.0L}\right) = \boxed{2.20 \times 10^{-4} \frac{M}{s}}$

f Plot would be curve. $\frac{1}{[CH_3CH_2NH_2]}$ would be straight if 2nd order. This is a 1st order Rxn so $\ln[CH_3CH_2NH_2]$ would be straight w/ - slope.

2012 Q4 a i $SrCO_3 + 2H^+ \rightarrow Sr^{2+} + H_2O + CO_2$

ii Bubbles or solid dissolves

b i $2Mg + O_2 \rightarrow 2MgO$

ii b/f : 0

after : +2

c i $Ni^{2+} + 2OH^- \rightarrow Ni(OH)_2$

ii Cl^-

2011 Q 2

a $CH_3OH \rightleftharpoons CO + 2H_2$

$[CH_3OH] = \frac{8.55 mol}{15.0 L}$ I 0.57M 0 0

C −0.42M +0.42m +0.84M

E 0.15M 0.42m 0.84M

$[CO]_{Eq} = \frac{6.3 mol}{15.0 L}$

$[H_2] = 0.84M \times 15.0L = $ 12.6mol H_2

ii $0.15M\ CH_3OH \times 15.0L \times \frac{32g\ CH_3OH}{1 mol\ CH_3OH} = $ 72.0g CH_3OH

(2.25mol)

iii $\frac{12.6 mol\ H_2}{(2.25 mol + 6.3 mol + 12.6 mol)} = $ 0.596

IV. $P = \frac{n_t RT}{V} = \frac{(21.2 mol)(0.0821)(600 K)}{15.0 L} = $ 69.8 atm

b N/A

c CO b/c CO is a little polar and so is methanol. polar solutes will dissolve in polar solvents

2011 Q3

a ~~CH2O~~ CH_2O

b $2.50g\ C_6H_{12}O_6 \times \frac{1\ mol\ C_6H_{12}O_6}{18.0g\ C_6H_{12}O_6} = 0.0139\ mol\ C_6H_{12}O_6$

$\frac{-39.0\ kJ}{0.0139\ mol\ C_6H_{12}O_6} = -2810\ \frac{kJ}{mol}$

c. i → iii N/A

d

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ $\Delta H = -2810\ \frac{kJ}{mol}$ (3 written above $6O_2$; 4 and 2 above $6CO_2$; 3 above $6H_2O$)

$2C_2H_5OH + 2CO_2 \rightarrow C_6H_{12}O_6$ $\Delta H = 68\ \frac{kJ}{mol}$

$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$ $\Delta H = -2742\ \frac{kJ}{mol}$

2011 Q4

a i $Zn + 2H^+ \rightarrow H_2 + Zn^{2+}$

ii $Zn \rightarrow Zn^{2+} + 2e^-$

b i $Li_2O + H_2O \rightarrow 2Li^+ + 2OH^-$

ii pH > 7 b/c OH^- is made which is a basic soln.

c. i $Sr^{2+} + CO_3^{2-} \rightarrow SrCO_3$

ii it will Bubble b/c CO_2 will be released in the Rxn. according the Eqn $SrCO_3 + 2H^+ \rightarrow H_2O + CO_2 + Sr^{2+}$

2011 Q5

a. ~~⊗~~ 100.0 mL × 1.250 M NaOH × $\frac{1 L}{5.00 M NaOH}$ = 25.0 mL

b 1. ~~I\[illegible\]~~ Fill a 100.0 mL Volumetric Flask ~~pour in~~ ½ full w/ distilled H_2O

2. In the 25 mL pipette, fill the pipette ~~up~~ ~~⊗~~ to the 5 mL mark. (After rinsing w/ NaOH soln)

3. Pour the 5 mL of NaOH into the volumetric flask and swirl soln. Fill the flask to the mark w/ distilled H_2O

4. Invert stoppered flask to mix the soln thoroughly.

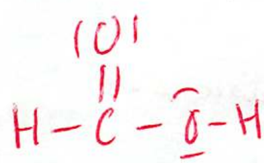
2011 Q6

a. i sp^2

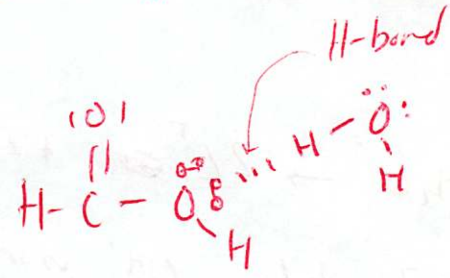
ii ~109.5° The C_y is tetrahedrally arranged. This give the Bond ∠ around

109.5°

b i



ii



C. i The ethyl methanoate evaporated into a gas which increased the P in the flask

ii an Equilibrium was reached where the rate of vaporization equals the Rate of condensation. There fore the P is constant

iii 0.25 atm

IV Stay the same, The liquid does not affect the Equilibrium present. additional liquid methanoate will not cause more evaporation

2009 Q2

a. Initial $[S_2O_3^{2-}]$

b. 1^{st} order b/c as the $[S_2O_3^{2-}]_0$ about doubles, the Rate of Rxn about doubles

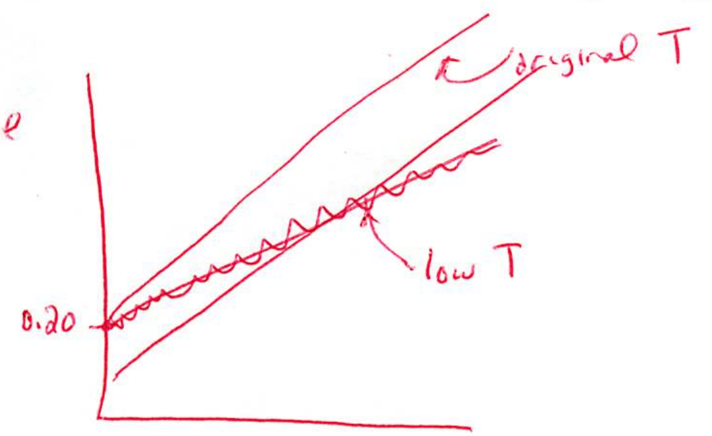
or $\frac{Rate_2}{Rate_1} = \frac{k[S_2O_3^{2-}]^n}{k[S_2O_3^{2-}]^n}$ $\frac{0.030\ M/s}{0.020\ M/s} = \frac{(0.075\ M)^n}{(0.050\ M)^n}$ — $(1.5)\ (1.5)^n \therefore m = 1$

c. $k = \frac{Rate_0}{[S_2O_3^{2-}]} = \frac{0.020\ \frac{M}{s}}{0.050\ M} = 0.40\ \frac{1}{s}$

d. $\ln(0.020\ M) = -kt + \ln(0.10\ M)$

$t = 4.0\ s$

e



2009 Q3

a $P_{O_2} = P_{atm} - P_{H_2O} = 762.6\ torr - 21.6\ torr = 741\ torr$

b $741\ torr \times \frac{1\ atm}{760\ torr} = 0.975\ atm$ $n = \frac{PV}{RT} = \frac{(0.975\ atm)(182.4\ mL \times \frac{1\ L}{1000\ mL})}{(0.0821\ \frac{L\ atm}{mol\ K})(273 + 23.4°C)}$

$= 7.31 \times 10^{-3}\ mol\ O_2$

c $7.31 \times 10^{-3}\ mol\ O_2 \times \frac{1\ mol\ H_2O_2}{1\ mol\ O_2} \times \frac{34\ g\ H_2O_2}{1\ mol\ H_2O_2} = 2.49 \times 10^{-1}\ g\ H_2O_2$

d $\frac{2.49 \times 10^{-1}\ g\ H_2O_2}{6.951\ g\ soln} \times 100\% = 3.57\%\ H_2O_2$

e. $H_2O_2 = -1$ $O_2 = 0$

f $H_2O_2 \rightarrow O_2 + 2H^+ + 2e^-$

2009 Q4

a i $Ba^{2+} + 2F^- \rightarrow BaF_2$

ii F^- is. b/c for each mol of Ba^{2+} you need 2mol F^- so F^- Runs out 1st.

b i $Cd + Cu^{2+} \rightarrow Cd^{2+} + Cu$

ii soln would lose blue color & a Reddish brown ppt forms

Q5 a V_i & V_f

b $(V_f - V_i) \times M\ NaOH$ = mol NaOH

c. Ans b $\times \frac{1\ mol\ HA}{1\ mol\ NaOH}$ = mol HA

d mass of unknown acid used

e $\frac{mass\ HA}{mol\ HA}$ = MM HA

f in Buret: Standardized NaOH

Flask: solid acid, H_2O, indicator

g i MM ↑ b/c g HA ↑ in calc □↑ so MM ↑

$\frac{g\ HA}{mol\ HA}$ = MM HA

ii No effect. The volume H_2O has no effect on the amount of NaOH used to neutralize the Acid.

2004 Q7

a Since ΔH is + the products have more PE than Reactants so the Bond strengths will be higher.

OR

Better → $\Delta H = BE_{React} - BE_{Prod}$ to get $+\Delta H$ $BE_{React} > BE_{prod.}$

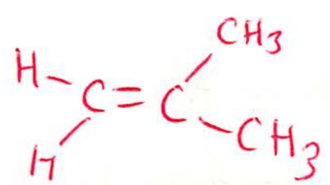
2004 Q8

a Trans 2 butene b/c $K > 1$ so products are favored.

b In container initial pressures of both gases would be equal b/c mol and volume are both equal. So $Q = 1$. Since $K > Q$ Equilibrium will shift to the Right

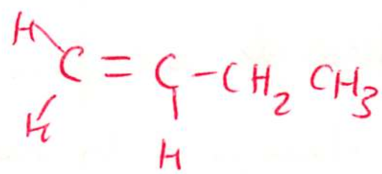
c. As T ↑, K↓ so products amount will decrease to make a smaller K. as Rxn shifts to the Left. So Rxn is exothermic

d



2methylpropene

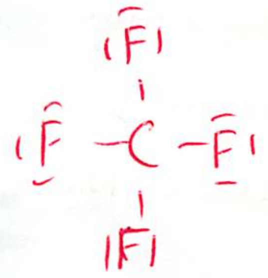
or

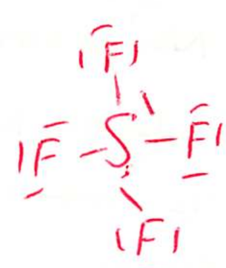


n - butene

2005 Q5

a



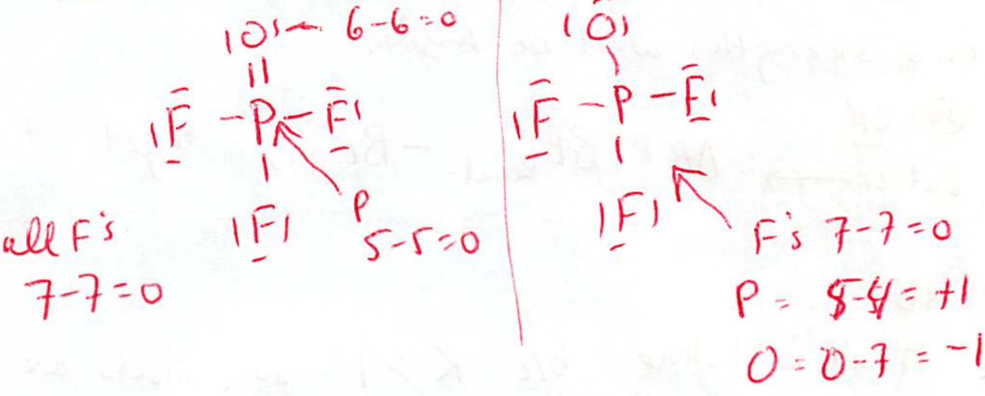


b i 109.5° ii. dsp^3 iii See saw.

2005 Q6 (con't)

c. i 4 σ , 1π

ii Left. ~~Formal Charge~~



So left xture has best layout b/c all FC's are 0.

2005 Q7

a i NH_3 → H-bonding, London Dispersion

NF_3 – Dipole Dipole, London Dispersion

ii Since H-bonds are stronger attractions than Dipole-Dipole there will be more E Req'd to break the H-bonds and BP will go ↑

b i Ionic Bonding in each

ii Since Na^+ is smaller than K^+ in ionic Radius the lattice energy will be higher in NaCl than KCl making it have a higher MP b/c more E is Req to Break xtal lattice according to Coulomb's Law $LE = k\frac{Q_1Q_2}{r}$ since r is smaller in NaCl LE ↑.

2005 7 Con't

c i n=3

ii across the period the effective nuclear charge of each element is increasing from Si → P → Cl. So as the Zeff ↑ the e^- are more strongly attracted to the nucleus so more E is Req'd to Remove the e^-'s

d i The element is Cu, b/c the Avg mass of Cu (63.5) is between the mass of each isotope (62.93 + 64.93 amu)

ii the one with a mass of 62.93 is more abundant than 64.93. This B/c the Avg mass of Cu is closer to 63.5. So it is more abundant.

2005B Q 5

a. Working in a fume hood, a student will fill a 50.0 mL volumetric flask w/ about ~~[struck out]~~ 20 mL of water using the graduated cylinder. Using the 25.0 mL pipette, slowly add 25.0 mL of H_2SO_4 to the water in the flask. As it spatters stop adding acid. Once all acid is added, mix the mixture and add water to the line on the flask and mix soln again.

b $$2.7g\ Al \times \frac{1\ mol\ Al}{27.0g\ Al} \times \frac{4\ H_2SO_4}{2\ mol\ Al} \times \frac{1}{5.0M\ H_2SO_4} = 0.020L = 20mL$$

0.1

c i Greater than. b/c actual mass appears higher than it should be and:

$$\frac{\boxed{\text{actual mass}}\uparrow}{\text{theoretical mass}} \times 100\% = \text{(\% yield)}$$ if actual ↑, % ↑

ii B/c the Alum is less soluble in H_2O @ lower T so more xtals ppt. and actual mass increase like above.

d B/c H_2O evap from crystals in the Rxn $KAl(SO_4)_2 \cdot 12H_2O \longrightarrow KAl(SO_4)_2 + 12H_2O\uparrow$

2005B Q6

a equal to B/c same moles in same volumes so P's are equal

b 6.2×10^21 J b/c H_2 + N_2 are @ same T so they have same Avg KE.

c. N/A

d Decrease T

e i P doubles b/c according to Boyles Law $V_1P_1 = V_2P_2$
if V ↓ by ½ P ↑ by 2.

2005 Q 7.

a ~~CH_3OH + 3/2 O_2 → 2 CO_2 + 4 H_2O~~ → $CH_3OH + \frac{3}{2}O_2 \rightarrow CO_2 + 2H_2O$

b $\Delta H = -730kJ - (+290kJ - 390kJ) = \boxed{-630kJ}$

c $C + H_2 + \frac{1}{2}O_2 \rightarrow CH_3OH$

d NA

e B/c H_2 has a higher BE than H_2O

Since ΔH is (−) BE_{React} must be lower than $BE_{~~React~~\ Prod}$

in the Eqn $\Delta H = BE_{Rea} - BE_{Prod}$

2005 Q8

a ~~[scribbled out]~~ $\bar{S}=C=\bar{S}$

b Se b/c Se atomic Radius is greater then S so the bond length will be longer

c Less b/c the Bond Length in CSe_2 is longer than CS_2 so there will be less attraction B/w atoms and less E will be needed to break the bonds.

d London Dispersion Prop

H-Bonds, Dipole Dipole, Lond Disp Meth.

e. Since H-Bond in methanol are very strong they will Require more E to over come and BP will be higher.

2007 Q1

a UO_2Cl_2 $9.734\times10^{-4}\ atm \times \frac{1\ O_2}{3\ UO_2Cl_2} = 3.24\times10^{-4}\ atm$

b $K_p = \frac{(9.734\times10^{-4}atm)^3(3.24\times10^{-4}atm)}{(1.007atm)^3} = 2.93\times10^{-13}$

c → e NA

f The Equilibrium will shif to the left and more U_3O_8 will ~~[struck]~~ deposit. so mass ↑.

2007 AP Q4

a i $(NH_4)_2CO_3 \longrightarrow 2NH_3 + H_2O + CO_2$

ii ΔS is higher @ end b/c more moles of products and all gases are made.

b i $Cl_2 + 2Br^- \rightarrow Br_2 + 2Cl^-$

ii Cl_2 bf = 0   After = -1

c i $Na + 2H_2O \rightarrow$ ~~2NaOH~~ $+ 2H_2 + 2Na^+ + 2OH^-$

ii H_2O vapor

2007 Q6

a Element 2, B/c it has the lowest IE

b Mg b/c the 3rd IE is the highest signifying a 3rd e^- is removal of a core e.

C. $1s^2\ 2s^2\ 2p^6\ 3s^2$

e Na

f element 1

2008 Q 1

a $K_p = \frac{(P_{CO})^2}{(P_{CO_2})}$

b ~~C + CO2 ⇌ 2CO~~

5.00 atm CO_2 = $P_{initial}$

$n = \frac{PV}{RT} = \frac{(2.00L)(5.00atm)}{(0.0821 \frac{L \cdot atm}{mol \cdot K})(1160K)} = 8.62 \times 10^{-2}$ moles

c. $C + CO_2 \rightleftharpoons 2CO$

	CO_2	CO
I	5.00atm	0
C	-3.37	+6.74
E	1.63atm	**6.74 atm** i

ii $K_p = \frac{(6.74atm)^2}{(1.63atm)} = $ **27.9**

d. Equal to. Catalysts will make the Rxn Reach Eq faster but will not affect the Eq [ ]'s

e. $Q = \frac{(2.00atm)^2}{(2.00atm)} = 2$

Eq Shift Right so P_{CO_2} will decrease b/c Q < K

2008 Q2

a Blc the mass b/w 2nd & 3rd heatings were only off by 0.001g.

b. i ~~23.976g~~ 25.825g − 23.976g = 1.849g H_2O × $\frac{1 \text{ mol } H_2O}{18 \text{ g } H_2O}$ = 0.1027 mol H_2O

ii mol $MgCl_2$ = (23.977g − 22.347g) × $\frac{1 \text{ mol } MgCl_2}{95.3 \text{ g } MgCl_2}$ = 0.0171 mol $MgCl_2$

$\frac{0.0171 \text{ mol } MgCl_2}{0.0171 \text{ mol } MgCl_2}$ = 1.0 mol $MgCl_2$: $\frac{0.1027 \text{ mol } H_2O}{0.0171 \text{ mol}}$ = 6 mol H_2O

$MgCl_2 \cdot 6H_2O$

c Mass lost ~~will go~~ will go ↑. Mass after heating will go ↓ so difference b/w mass BF and after is larger appearing that more water was lost

d. Add $AgNO_3$ soln to mixture soln until ppt stops. Collect ppt by gravity filtration. wash ppt w/water to remove any residual spectator ions. dry ppt and weigh it until a constant mass is reached.

$MgCl_2 + 2AgNO_3 \rightarrow 2AgCl + Mg(NO_3)_2$

e. i 5.48g AgCl × $\frac{1 \text{ mol AgCl}}{143.4 \text{ g AgCl}}$ × $\frac{1 \text{ mol } MgCl_2}{2 \text{ mol AgCl}}$ = 0.0191 mol $MgCl_2$

ii 0.0191 mol $MgCl_2$ × $\frac{95.3 \text{ g } MgCl_2}{1 \text{ mol } MgCl_2}$ = $\frac{1.82 \text{ g } MgCl_2}{5.48 \text{ g}}$ × 100% = 33.2%

2008 (Last Q in packet

d ii

$$\frac{Rate_2}{Rate_1} = \frac{k_1 [NO]^m [O_2]^n}{k_1 [NO]^m [O_2]^n} \longrightarrow \frac{2.56 \times 10^{-1} \frac{M}{s}}{8.52 \times 10^{-2} \frac{M}{s}} = \frac{k (0.0200 M)^m (0.0900 M)^n}{k (0.0200 M)^m (0.0300 M)^n}$$

$$3.00 = (3.00)^n \quad \boxed{n = 1}$$

e

$$\frac{Rate_3}{Rate_1} = \frac{k [NO]^m [O_2]^n}{k [NO]^m [O_2]^n} \longrightarrow \frac{7.67 \times 10^{-1} \frac{M}{s}}{8.52 \times 10^{-2} \frac{M}{s}} = \frac{k (0.0600)^m (0.0300 M)^n}{k (0.0200 M)^m (0.0300 M)^n}$$

$$9 = (3)^m \quad \boxed{m = 2}$$

e $Rate = k [NO]^2 [O_2]$

f

$$k = \frac{Rate}{[NO]^2 [O_2]} = \frac{8.52 \times 10^{-2} \frac{M}{s}}{(0.0200 M)^2 (0.0300 M)} = \boxed{7.10 \times 10^3 \frac{1}{M s}}$$